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DEFENSE HEALTH CARE

Issues Related to Past Drinking Water Contamination at Marine Corps Base Camp Lejeune

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DEFENSE HEALTH CARE

Issues Related to Past Drinking Water Contamination at Marine Corps Base Camp Lejeune

Why GAO Did This Study

In the early 1980s, volatile organic compounds (VOC) were discovered in some of the water systems serving housing areas on Marine Corps Base Camp Lejeune. Exposure to certain VOCs may cause adverse health effects, including cancer. Since 1991, the Department of Health and Human Services' Agency for Toxic Substances and Disease Registry (ATSDR) has been examining whether individuals who were exposed to the contaminated drinking water are likely to have adverse health effects. ATSDR's current study is examining whether individuals who were exposed in utero are more likely to have developed certain childhood cancers or birth defects.

GAO was asked to testify on its May 11, 2007 report: *Defense Health Care: Activities Related to Past Drinking Water Contamination at Marine Corps Base Camp Lejeune* ([GAO-07-276](#)). This testimony summarizes findings from the report about (1) efforts to identify and address the past drinking water contamination, (2) the provision of funding and information from the Department of Defense (DOD) to ATSDR, and (3) an assessment of the design of the current ATSDR study. GAO reviewed documents, interviewed officials and former residents, and contracted with the National Academy of Sciences to convene an expert panel to assess the current ATSDR study.

www.gao.gov/cgi-bin/getrpt?GAO-07-933T

To view the full product, including the scope and methodology, click on the link above. For more information, contact Marcia Crosse at (202) 512-7119 or crossem@gao.gov.

What GAO Found

Efforts to identify and address the past drinking water contamination at Camp Lejeune began in the 1980s, when Navy water testing at Camp Lejeune detected VOCs in some base water systems. In 1982 and 1983, continued testing identified two VOCs—trichloroethylene (TCE), a metal degreaser, and tetrachloroethylene (PCE), a dry cleaning solvent—in two water systems that served base housing areas, Hadnot Point and Tarawa Terrace. In 1984 and 1985 a Navy environmental program identified VOCs, such as TCE and PCE, in some of the individual wells serving the Hadnot Point and Tarawa Terrace water systems. Ten wells were subsequently removed from service. DOD and North Carolina officials concluded that on- and off-base sources were likely to have caused the contamination. It has not been determined when contamination at Hadnot Point began. ATSDR has estimated that well contamination at Tarawa Terrace from an off-base dry cleaner began as early as 1957.

Since ATSDR began its Camp Lejeune-related work in 1991, the agency has not always received requested funding and has experienced delays in receiving information from DOD. However, ATSDR officials said that while funding and access to records were probably slowed down and made more expensive by DOD officials' actions, their actions did not significantly impede ATSDR's Camp Lejeune-related health study efforts. The ATSDR officials also stated that while issues such as limitations in access to DOD data had to be addressed, such situations are normal during the course of a study.

Members of the expert panel that the National Academy of Sciences convened for GAO generally agreed that many parameters of ATSDR's current study are appropriate, including the study population, the exposure time frame, and the selected health effects. Regarding the study's proposed completion date of December 2007, the panel experts had mixed opinions: three of the five panel experts who commented said that the projected date appeared reasonable, while two said that the date might be optimistic.

DOD, the Environmental Protection Agency, and the Department of Health and Human Services provided technical comments on a draft of the May 11, 2007 report, which GAO incorporated where appropriate. Three members of an ATSDR community assistance panel for Camp Lejeune provided oral comments on issues such as other VOCs that have been detected at Camp Lejeune, and compensation, health benefits, and additional notification for former residents. GAO focused its review on TCE and PCE because they were identified by ATSDR as the chemicals of primary concern. GAO's report notes that other VOCs were detected. GAO incorporated the panel members' comments where appropriate, but some issues were beyond the scope of the report.

Mr. Chairman and Members of the Subcommittee:

I am pleased to be here today as you examine issues related to past drinking water contamination at Camp Lejeune. In the early 1980s, Department of the Navy water testing at Marine Corps Base Camp Lejeune identified contamination in water systems that served housing areas on the base.¹ Further water testing revealed that some of the individual wells serving two of the water systems were contaminated with volatile organic compounds (VOC), such as trichloroethylene (TCE), which is a metal degreaser and an ingredient in adhesives and paint removers, and tetrachloroethylene (PCE), which is a solvent used in the textile industry and a dry cleaning solvent. Although it is not known precisely when the wells became contaminated, the Department of Health and Human Services' (HHS) Agency for Toxic Substances and Disease Registry (ATSDR), which is investigating the issue, has estimated that the contamination may have begun as early as the 1950s. According to ATSDR, the VOCs of primary concern at Camp Lejeune were TCE and PCE, and the agency notes that exposure to these chemicals may cause adverse health effects. For example, exposure to low levels of TCE may cause headaches and difficulty concentrating.² Exposure to high levels of both TCE and PCE may cause dizziness, headaches, nausea, unconsciousness, cancer, and possibly death.³

Former residents of Camp Lejeune have taken legal action against the federal government for injuries alleged to have resulted from exposure to the contaminated water. As of June 2007, about 850 former residents and former employees of Camp Lejeune have filed tort claims with the Department of the Navy related to the past drinking water contamination. Two of these claims have resulted in the filing of lawsuits in Federal District Courts in Texas and Mississippi.⁴ In addition, some former

¹Water testing was conducted at Camp Lejeune in preparation for meeting future drinking water regulations and to address concerns about chemicals that had been buried on base.

²According to ATSDR, health effects from exposure to low levels of PCE are unknown.

³ATSDR did not define "low levels" or "high levels" of TCE or PCE.

⁴*Snyder et al. v. U.S.*, Civ. No. 627 (S.D. Miss. filed July 27, 2004); *Gros et al. v. U.S.*, Civ. No. 4665 (S. D. Tex. filed Dec. 13, 2004). The Federal Tort Claims Act requires that a claim must be presented in writing within 2 years after the claim accrues and that after a claim has been filed the agency has 6 months to make a decision. If the claim is denied or if no decision has been made after 6 months, the individual can then file a lawsuit against the federal government. 28 U.S.C. § 2675. The lawsuits were filed in the districts where the individuals resided at the time.

residents have expressed concern over the Marine Corps' handling of and response to the drinking water contamination, noting that even though contaminants were detected as early as 1980, the wells that were determined to be contaminated were not removed from service until 1985. Some former residents have also asserted that there have been delays in the provision of funding and information from the Department of Defense (DOD) to ATSDR.⁵

My statement is based on our May 11, 2007 report, *Defense Health Care: Activities Related to Past Drinking Water Contamination at Marine Corps Base Camp Lejeune* (GAO-07-276). For this report, the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 directed that we study and report on the past drinking water contamination and related adverse health effects at Camp Lejeune, including identifying the type, source, and duration of the contamination and determining the actions taken to address the contamination, and assessing the current ATSDR health study.⁶ My remarks today will summarize our findings related to the history of events related to drinking water contamination at Camp Lejeune, specifically, (1) efforts to identify and address the past contamination; (2) the provision of funding and information from DOD to ATSDR for its work related to the past contamination at Camp Lejeune; and (3) an assessment by an independent panel of experts of the design of the current ATSDR health study, including the study's population, the exposure time frame, selected health effects being measured, and the reasonableness of the projected completion date.

To do this work, we reviewed more than 1,600 documents related to past and current drinking water activities at Camp Lejeune. We focused our review on the past TCE and PCE contamination⁷ because ATSDR had noted that these chemicals were the VOCs of primary concern at Camp Lejeune. However, we also reviewed documentation regarding other VOCs detected at Camp Lejeune. For this testimony we focused on

⁵DOD is required by law to provide funding and data as necessary for ATSDR to carry out certain health-related activities, including public health assessments.

⁶Pub. L. No. 108-375, § 317, 118 Stat. 1811, 1844.

⁷Throughout this testimony we use the term "contamination," which is also used by the law requiring us to do this work, as well as by the EPA and DOD, to describe the drinking water at Camp Lejeune in the early 1980s. However, EPA had not yet established maximum contaminant levels for the chemicals TCE and PCE during this period. See 40 C.F.R. §§ 141.2 and 141.12 (1975-1985).

contamination in Camp Lejeune's Hadnot Point, Tarawa Terrace, and Holcomb Boulevard water systems, as they provided drinking water to most of the installation's housing areas during the period of interest. We interviewed current and former officials from various DOD entities, including Camp Lejeune, Headquarters Marine Corps, and the Department of the Navy, to obtain information about the history of events related to the past drinking water contamination at Camp Lejeune, including efforts to identify and address the contamination. The current and former officials interviewed often provided information based on their memory of events that occurred more than 20 years ago. We attempted to corroborate their testimonial evidence with documentation whenever possible. The former officials we interviewed were responsible for environmental activities at Camp Lejeune or the Department of the Navy during the time in which the contamination was detected. The current officials we interviewed are responsible for environmental activities at Camp Lejeune, Headquarters Marine Corps, or the Department of the Navy. Some of these current officials were also responsible for environmental activities during the time in which the contamination was detected. We also met with 19 interested former residents and individuals who worked on the base during the 1960s, 1970s, and 1980s, in order to obtain their perspective on historical events and to learn about their concerns related to the drinking water contamination. A former resident who is active in matters related to the past drinking water contamination at Camp Lejeune identified most of the interested former residents; others were identified at an ATSDR public meeting. Additionally, we examined reports from and interviewed officials with the Environmental Protection Agency (EPA) and with the North Carolina Department of Environment and Natural Resources who were knowledgeable about activities and costs related to the cleanup of the suspected sources of contamination. We also interviewed ATSDR officials and reviewed ATSDR's Camp Lejeune-related documents and publications, including a 1997 public health assessment and an ATSDR health study released in 1998. We also interviewed officials with the Department of the Navy and the U.S. Army Center for Health Promotion and Preventive Medicine, which serves as a liaison between DOD and ATSDR. To assess the design of the current ATSDR health study, we contracted with the National Academy of Sciences (NAS) to convene a panel of seven subject area experts for a 1-day meeting. The expert panel was charged with evaluating the study's population, exposure time frame, selected health effects, and completion date. We relied primarily on information gleaned from the expert panel meeting and the panel experts' subsequent written responses to the set of questions that were discussed during the 1-day meeting. Not all panel members commented individually about each of the questions discussed during the 1-day meeting. Additionally, some panel

members noted that certain questions addressed subjects that were outside their areas of expertise. We also reviewed study-related documentation furnished by officials from ATSDR, the Marine Corps, and the Navy Environmental Health Center, and interviewed officials from those agencies. We conducted our work from May 2005 through April 2007 in accordance with generally accepted government auditing standards.

In summary, we found that efforts to identify and address past drinking water contamination at Camp Lejeune began in the 1980s, when the Navy initiated water testing, and are continuing with long-term cleanup and monitoring. In 1980, VOCs, including TCE, were first detected at Camp Lejeune during an analysis by a Navy-contracted laboratory that combined treated water from all base water systems. During the same year, the Navy began monitoring Camp Lejeune's treated water for total trihalomethanes (TTHMs), contaminants that are a by-product of the water treatment process. The TTHM monitoring indicated interference from unidentified chemicals. In 1982 and 1983, continued TTHM monitoring identified TCE and another VOC, PCE, as contaminants in two separate water systems that served base housing areas, Hadnot Point and Tarawa Terrace. Sampling results indicated that the levels of TCE and PCE found in the water systems varied. Former Camp Lejeune environmental officials said that they did not take additional steps to address the contamination after TCE and PCE were identified. The former officials recalled that they did not act because at that time they had little knowledge about TCE and PCE, there were no drinking water regulations that gave enforceable limits for these chemicals, and variation in water testing results raised questions about the tests' validity. Also in 1982, a Navy environmental program began investigating potentially contaminated sites at many Marine Corps and Navy bases, including Camp Lejeune. Testing initiated under that program in 1984 and 1985 found that individual wells in the Hadnot Point and Tarawa Terrace water systems were contaminated with TCE, PCE, and other VOCs. Camp Lejeune officials removed 10 contaminated wells from service in 1984 and 1985. Camp Lejeune officials determined that several areas on base where hazardous waste and other materials were disposed of may have been the sources of contamination for the Hadnot Point water system, and North Carolina environmental officials determined that an off-base dry cleaner was the likely source of contamination for the Tarawa Terrace water system. Efforts are ongoing by ATSDR to determine when contamination at Hadnot Point began. In 2006, ATSDR estimated that well contamination from the off-base dry cleaner began as early as 1957. In 1989, both Camp Lejeune and the off-base dry cleaner were placed on EPA's National Priorities List.

Regarding the provision of funding and information from DOD to ATSDR for its work related to the past contamination at Camp Lejeune, we found that since ATSDR began its Camp Lejeune-related work in 1991, the agency has not always received requested DOD funding and experienced delays in receiving information from DOD. For example, for 3 of the 16 fiscal years during which ATSDR has conducted its Camp Lejeune-related work (fiscal years 1998 through 2000), no funding was provided to ATSDR by the Navy or any DOD entity. ATSDR also had difficulties getting documents needed from Camp Lejeune while it was conducting a public health assessment for the base. However, ATSDR officials said that while funding and access to records were probably slowed down and their Camp Lejeune related work made more expensive by DOD officials' actions, their actions did not significantly impede ATSDR's Camp Lejeune-related health study efforts. The ATSDR officials also stated that while issues such as limitations in access to DOD data had to be addressed, such situations are normal during the course of a study.

The experts convened by NAS to assess the design of the current ATSDR health study generally agreed that many parameters of ATSDR's current study are appropriate. Regarding the study population, all seven panel experts agreed that ATSDR's study population of individuals who were potentially exposed in utero to the contaminated drinking water at Camp Lejeune between 1968 and 1985 was appropriate, as this population was arguably the most vulnerable to the effects of the contamination. Panel experts generally agreed that the 1968-1985 study time frame was reasonable, based on limitations in data availability for the years prior to 1968. Regarding the health effects studied, five of the seven panel experts discussed health effects and said that the selected birth defects and childhood cancers were relevant. Regarding the proposed completion date, the panel experts had mixed opinions: three of the five panel experts who commented said that the projected December 2007 date appeared reasonable, while two said that the date might be optimistic.

DOD, EPA, and HHS provided technical comments on a draft of the May 11, 2007 report, which we incorporated where appropriate. We provided the seven former Camp Lejeune residents who are members of an ATSDR community assistance panel for Camp Lejeune the opportunity to provide comments on our draft—three of the panel members provided both technical and general oral comments, and four declined to review the draft report. The three panel members commented generally on issues such as VOCs other than TCE and PCE that have been detected at Camp Lejeune, compensation and health benefits for former residents, and additional notification for former residents. We incorporated the panel

members' technical comments where appropriate, but some issues they discussed were beyond the scope of the report.

Background

Drinking water can come from either groundwater sources, via wells, or from surface water sources, such as rivers, lakes, and streams. All sources of drinking water contain some naturally occurring contaminants. As water flows in streams, sits in lakes, and filters thorough layers of soil and rock in the ground, it dissolves or absorbs the substances that it touches. Some of these contaminants are harmless, but others can pose a threat to drinking water, such as improperly disposed-of chemicals, pesticides, and certain naturally occurring substances. Likewise, drinking water that is not properly treated or disinfected, or which travels through an improperly maintained water system, may pose a health risk. However, the presence of contaminants does not necessarily indicate that water poses a health risk—all drinking water may reasonably be expected to contain at least small amounts of some contaminants. As of July 2006, EPA had set standards for approximately 90 contaminants in drinking water that may pose a risk to human health. According to EPA, water that contains small amounts of these contaminants, as long as they are below EPA's standards, is safe to drink. However, EPA notes that people with severely compromised immune systems and children may be more vulnerable to contaminants in drinking water than the general population.

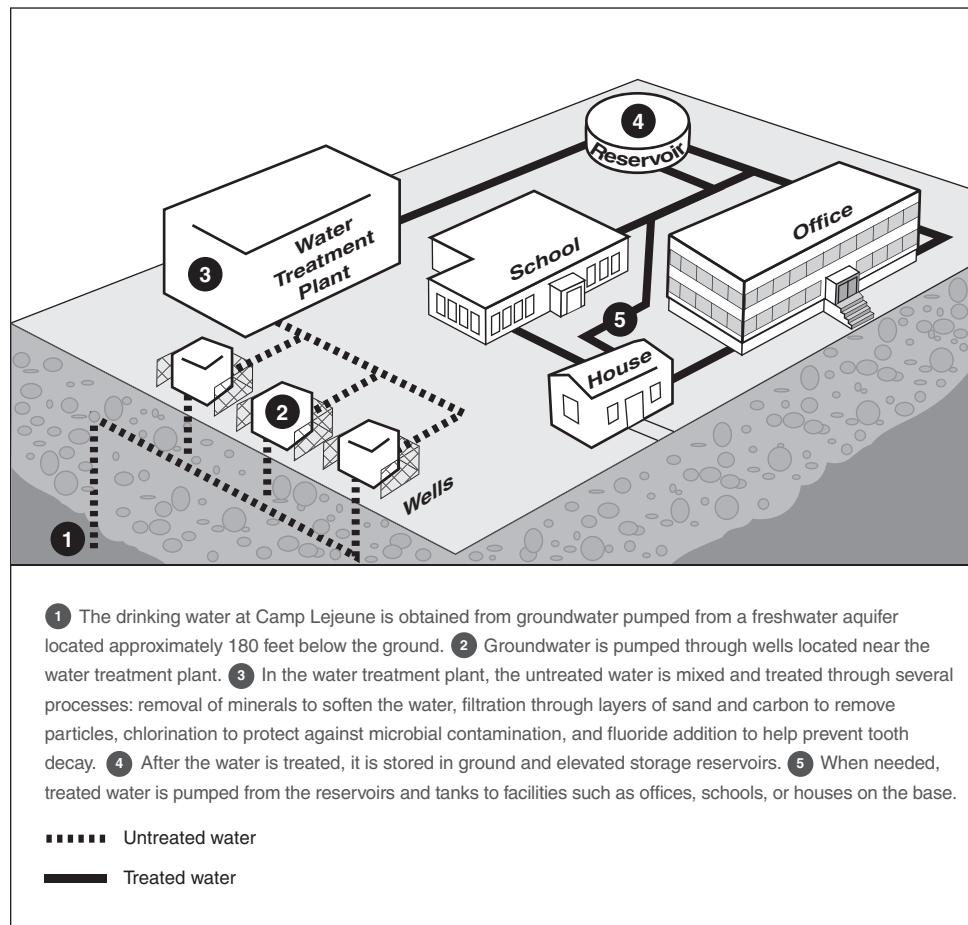
General Information about Camp Lejeune and Its Water Systems

Camp Lejeune covers approximately 233 square miles in Onslow County, North Carolina, and includes training schools for infantry, engineers, service support, and medical support, as well as a Naval Hospital and Naval Dental Center. The base has nine family housing areas, and families live in base housing for an average of 2 years. Base housing at Camp Lejeune consists of enlisted family housing, officer family housing, and bachelor housing (barracks for unmarried service personnel). Additionally, schools, day care centers, and administrative offices are located on the base. Approximately 54,000 people currently live and work at Camp Lejeune, including about 43,000 active duty personnel and 11,000 military dependents and civilian employees.

In the 1980s, Camp Lejeune obtained its drinking water from as many as eight water systems, which were fed by more than 100 individual wells that pumped water from a freshwater aquifer located approximately 180 feet below the ground. Each of Camp Lejeune's water systems included wells, a water treatment plant, reservoirs, elevated storage tanks, and distribution lines to provide the treated water to the systems' respective

service areas. Drinking water at Camp Lejeune has been created by combining and treating groundwater from multiple individual wells that are rotated on and off, so that not all wells are providing water to the system at any given time. Water is treated in order to remove minerals and particles and to protect against microbial contamination. (See fig. 1 for a description of how a Camp Lejeune water system operates.)

Figure 1: Conceptual Model of a Camp Lejeune Water System



Sources: GAO, Art Explosion, and Marine Corps Base Camp Lejeune.

Note: Water treatment processes may not remove all contaminants present in untreated water.

From the 1970s through 1987, Hadnot Point, Tarawa Terrace, and Holcomb Boulevard water systems provided drinking water to most of Camp Lejeune's housing areas. The water treatment plants for the Hadnot Point and Tarawa Terrace water systems were constructed during the 1940s and 1950s. The water treatment plant for the Holcomb Boulevard water system began operating at Camp Lejeune in 1972; prior to this time, the Hadnot Point water system provided water to the Holcomb Boulevard service area. In the 1980s, each of these three systems had between 8 and 35 wells that could provide water to their respective service areas. In 1987 the Tarawa Terrace water treatment plant was shut down and the Holcomb Boulevard water distribution system was expanded to include the Tarawa Terrace water service area.

Generally, housing units served by the Tarawa Terrace and Holcomb Boulevard water systems consisted of family housing, which included single- and multifamily homes and housing in trailer parks. Housing units served by the Hadnot Point water system included mainly bachelor housing with limited family housing. Based on available housing data for the late 1970s and the 1980s,⁸ the estimated annual averages of the number of people living in family housing units⁹ served by these water systems at that time were:

- 5,814 people in units served by the Tarawa Terrace water system,
- 6,347 people in units served by the Holcomb Boulevard water system, and
- 71 people in units served by the Hadnot Point water system.

In addition to serving housing units, all three water systems provided water to base administrative offices. The Tarawa Terrace, Holcomb Boulevard, and Hadnot Point water systems also served schools and other recreational areas. Additionally, the Hadnot Point water system also served an industrial area and the base hospital.

⁸To determine the estimated annual average of people who lived in family housing units served by these four water systems, we used limited housing data from 1977 to 1989 provided to us by Camp Lejeune officials. Camp Lejeune officials could not provide housing data prior to 1977.

⁹Camp Lejeune housing officials could not provide occupancy rates for bachelor housing.

Department of the Navy Environmental Functions

Certain Navy entities provide support functions for Marine Corps bases such as Camp Lejeune. Two entities provide support for environmental issues:

- The Naval Facilities Engineering Command began providing environmental support for bases in the 1970s. The Naval Facilities Engineering Command, Atlantic Division (LANTDIV) provides environmental support for Navy and Marine Corps bases in the Atlantic and mid-Atlantic regions of the United States.¹⁰ For example, LANTDIV officials work with Camp Lejeune officials to establish environmental cleanup priorities and cost estimates and to allocate funding to ensure compliance with state and federal environmental regulations.
- The Navy Environmental Health Center (NEHC) has provided environmental and public health consultation services for Navy and Marine Corps environmental cleanup sites since 1991. NEHC is also designated as the technical liaison between Navy and Marine Corps installations and ATSDR and, as a part of this responsibility, reviews and comments on all ATSDR reports written for Navy and Marine Corps sites prior to publication. Prior to 1991, no agency was designated to provide public health consultation services for Navy and Marine Corps sites.

In 1980, the Department of the Navy established the Navy Assessment and Control of Installation Pollutants (NACIP) program to identify, assess, and control environmental contamination from past hazardous material storage, transfer, processing, and disposal operations. Under the NACIP program, initial assessment studies were conducted to determine the potential for environmental contamination at Navy and Marine Corps bases. If, as a result of the study, contamination was suspected, a follow-up confirmation study and corrective measures were initiated. In 1986 the Navy replaced its NACIP program with the Installation Restoration Program. The purpose of the Installation Restoration Program is to reduce, in a cost-effective manner, the risk to human health and the environment from past waste disposal operations and hazardous material spills at Navy and Marine Corps bases. Cleanup is done in partnership with EPA, state regulatory agencies, and members of the community.

¹⁰LANTDIV also manages the planning, design, construction, contingency engineering, real estate, and public works support at Navy and Marine Corps facilities in the United States.

Environmental Laws and Regulations Related to Drinking Water Contamination and Hazardous Waste Contamination at Camp Lejeune

Congress passed the Safe Drinking Water Act in 1974¹¹ to protect the public's health by regulating the nation's public drinking water supply. The Safe Drinking Water Act, as amended, is the key federal law protecting public water supplies from harmful contaminants. For example, the act requires that all public water systems conduct routine tests of treated water to ensure that the water is safe to drink. Required water testing frequencies vary and range from weekly testing for some contaminants to testing every 3 years for other contaminants. The act also established a federal-state arrangement in which states may be delegated primary implementation and enforcement authority for the drinking water program. For contaminants that are known or anticipated to occur in public water systems and that EPA determines may have an adverse impact on health, the act requires EPA to set a nonenforceable maximum contaminant level goal, at which no known or anticipated adverse health effects occur and that allows an adequate margin of safety. Once the maximum contaminant level goal is established, EPA sets an enforceable standard for water as it leaves the treatment plant, the maximum contaminant level. A maximum contaminant level is the maximum permissible level of a contaminant in water delivered to any user of a public water system. The maximum contaminant level must be set as close to the goal as is feasible using the best technology or other means available, taking costs into consideration. The North Carolina Department of Environment and Natural Resources and its predecessors¹² have had primary responsibility for implementation of the Safe Drinking Water Act in North Carolina since 1980.

In 1979, EPA promulgated final regulations applicable to certain community water systems establishing the maximum contaminant levels for the control of TTHMs, which are a type of VOC that are formed when disinfectants—used to control disease-causing contaminants in drinking water—react with naturally occurring organic matter in water. The regulations required that water systems that served more than 10,000 people and that added a disinfectant as part of the drinking water

¹¹Pub. L. No. 93-523, 88 Stat. 1660 (codified, as amended, at 42 U.S.C. §§ 300f et seq.).

¹²In the 1980s, the North Carolina Department of Human Resources administered the Safe Drinking Water Act and the Department of Natural Resources and Community Development was responsible for other environmental functions in the state of North Carolina. In 1989, sections of these departments underwent a reorganization and name change, becoming the Department of Environment, Health, and Natural Resources. In 1997, the department was again reorganized and took on its current name, the Department of Environment and Natural Resources.

treatment process begin mandatory water testing for TTHMs by November 1982 and comply with the maximum contaminant level by November 1983. TCE and PCE were not among the contaminants included in these regulations.

In 1979 and 1980, EPA issued nonenforceable guidance establishing “suggested no adverse response levels” for TCE and PCE in drinking water and in 1980 issued “suggested action guidance” for PCE in drinking water.¹³ Suggested no adverse response levels provided EPA’s estimate of the short- and long-term exposure to TCE and PCE in drinking water for which no adverse response would be observed and described the known information about possible health risks for these chemicals. Suggested action guidance recommended remedial actions within certain time periods when concentrations of contaminants exceeded specific levels. Suggested action guidance was issued for PCE related to drinking water contamination from coated asbestos-cement pipes, which were used in water distribution lines.

The initial regulation of TCE and PCE under the Safe Drinking Water Act began in 1989 and 1992, respectively, when maximum contaminant levels became effective for these contaminants. (See table 1 for the suggested no adverse response levels, suggested action guidance, and maximum contaminant level regulations for TCE and PCE.)

¹³Neither issuance was published in *The Federal Register*.

Table 1: EPA Guidance and Regulations for Trichloroethylene (TCE) and Tetrachloroethylene (PCE) in Drinking Water

Chemical	Nonenforceable guidance			Enforceable regulation		
	1-Day ^d	10-Day ^e	Long-term ^f	1-Day ^d	10-Day ^e	Long-term ^f
TCE	2,000	200	75	N/A ^g	N/A ^g	N/A ^g
PCE	2,300	175	20	2,300	180	40

Source: GAO analysis of EPA data.

^aSuggested no adverse response levels are EPA-issued nonenforceable guidance for community water systems regarding TCE and PCE in drinking water.

^bSuggested action guidance is EPA-issued nonenforceable guidance suggesting that remedial action be taken when PCE exceeded specific levels.

^cThese are the maximum permissible levels of a contaminant in water that is delivered to a public water system. Maximum contaminant levels are not specific to period of exposure. The maximum contaminant level for TCE became effective in 1989. *See 52. Fed. Reg. 25716* (July 8, 1987). The maximum contaminant level for PCE became effective in 1992. *See 52. Fed. Reg. 3593* (Jan. 30, 1991). The maximum contaminant levels were issued in milligrams per liter. EPA also reports these contaminant levels in the equivalent ppb.

^dOne-day suggested no adverse response levels and suggested action guidance were the maximum levels for one 24-hour period of exposure.

^eTen-day suggested no adverse response levels and suggested action guidance were the maximum levels each day for 10 days of exposure.

^fLong-term suggested no adverse response levels and suggested action guidance were the maximum levels each day for long-term exposure. Long-term exposure was based on a 70-year exposure.

^gThere was no suggested action guidance for TCE.

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980¹⁴ established what is known as the Superfund program to clean up highly contaminated waste sites and address the threats that these sites pose to human health and the environment, and assigned responsibility to EPA for administering the

¹⁴Pub. L. No. 96-510, 94 Stat. 2767 (codified, as amended, at 42 U.S.C. §§ 9601 et seq.).

program.¹⁵ CERCLA was amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986.¹⁶ Among other things, SARA requires that federal agencies, including DOD, that own or operate facilities on EPA's CERCLA list of seriously contaminated sites, known as the National Priorities List, enter into an interagency agreement with EPA.¹⁷ The agreement is to specify what cleanup activities, if any, are required and to set priorities for carrying out those activities.¹⁸ SARA also established the Defense Environmental Restoration Program, through which DOD conducts environmental cleanup activities at military installations.¹⁹ Under the environmental restoration program, DOD's activities addressing hazardous substances, pollutants, or contaminants are required to be carried out consistent with the provisions of CERCLA governing environmental cleanups at federal facilities.²⁰ Based on environmental contamination at various areas on the base, Camp Lejeune was designated as a National Priorities List site in 1989. EPA, the Department of the Navy, and the state of North Carolina entered into a Federal Facilities Agreement concerning cleanup of Camp Lejeune with an effective date of March 1, 1991.

ATSDR's Assessment of the Adverse Health Effects of Hazardous Substances at DOD Superfund Sites

ATSDR was created by CERCLA and established within the Public Health Service of HHS in April 1983 to carry out Superfund's health-related activities. These activities include conducting health studies, laboratory projects, and chemical testing to determine relationships between exposure to toxic substances and illness. In 1986, SARA expanded

¹⁵At privately owned sites, EPA can require that responsible parties either perform the cleanup themselves or reimburse EPA for the costs of Superfund-funded cleanups. Federal agencies generally must pay for cleanups and other Superfund activities from their own appropriations.

¹⁶Pub. L. No. 99-499, 100 Stat. 1613 (1986) (codified, as amended, at various sections of titles 10, 26, 29, and 42 U.S.C.).

¹⁷To determine which sites are eligible for listing on the National Priorities List, EPA uses the Hazard Ranking System, a numerical scoring system that assesses the hazards a site poses to human health and the environment as its principal determining factor. Once EPA has determined that the risks posed by a site make it eligible for the National Priorities List, EPA regions then consider many other factors in selecting the sites to submit to EPA headquarters for proposal to be added to the National Priorities List.

¹⁸See 42 U.S.C. § 9620(e).

¹⁹See 10 U.S.C. §§ 2701-2709.

²⁰See 10 U.S.C. § 2701(a)(2).

ATSDR's responsibilities to include, among other things, conducting public health assessments, toxicological databases, information dissemination, and medical education. SARA requires that ATSDR conduct a public health assessment at each site proposed for or on the National Priorities List, and that ATSDR conduct additional follow-up health studies if needed. Potentially responsible parties, including federal agencies, are liable for the costs of any health assessment or health effects study carried out by ATSDR.²¹

SARA requires that ATSDR and DOD enter into a memorandum of understanding to set forth the authorities, responsibilities, and procedures between DOD and ATSDR for conducting public health activities at DOD Superfund sites.²² Based on the memorandum of understanding signed between ATSDR and DOD, ATSDR is required to submit an annual plan of work to DOD, in which it must describe the public health activities it plans to conduct at DOD sites in the following fiscal year, as well as the amount of funding required to conduct these activities. After the annual plan of work has been submitted, DOD has 45 days to respond and negotiate the scope of work to be conducted by ATSDR. The memorandum of understanding states that DOD must seek sufficient funding through the DOD budgetary process to carry out the work agreed upon.

From 1991 to 1997, ATSDR conducted a public health assessment at Camp Lejeune that was required by law because of the base's listing on the National Priorities List. The health assessment evaluated several ways in which people on base had been exposed to hazardous substances, including exposure to the VOC-contaminated drinking water.²³ In its 1997 report, ATSDR recommended that a study be carried out to evaluate the risks of childhood cancer in those who were exposed in utero to the contaminated drinking water and also noted that adverse pregnancy outcomes were of concern. In 1995, while the health assessment was being conducted, ATSDR initiated a study to determine whether there was an association between exposure to VOCs in drinking water and specific adverse pregnancy outcomes among women who had lived at Camp

²¹See 42 U.S.C. § 9607(a)(4)(D).

²²See 10 U.S.C. § 2704(c).

²³While conducting the health assessment, ATSDR also considered two other types of past exposures at Camp Lejeune as possibly posing a public health hazard: lead in tap water and pesticides in soil at a former day care facility.

Lejeune from 1968 through 1985.²⁴ The study, released in 1998, originally concluded that there was a statistically significant elevated risk for several poor pregnancy outcomes, including (1) small for gestational age among male infants born to mothers living at Hadnot Point, (2) small for gestational age for infants born to mothers over 35 years old living at Tarawa Terrace, and (3) small for gestational age for infants born to mothers with two or more prior fetal losses living at Tarawa Terrace.²⁵ However, ATSDR officials said they are reanalyzing the findings of this study because of an error in the original assessment of exposure to VOCs in drinking water. While the study originally assessed births from 1968 to 1972 in the Holcomb Boulevard service area as being unexposed to VOCs, these births were exposed to contaminants from the Hadnot Point water system. An ATSDR official said the reanalysis may alter the study's results.

In 1999, ATSDR initiated its current study examining whether certain birth defects and childhood cancers are associated with exposure to TCE or PCE at Camp Lejeune. The study examines whether individuals born during 1968 through 1985 to mothers who were exposed to the contaminated drinking water at any time while they were pregnant and living at Camp Lejeune were more likely than those who were not exposed to have neural tube defects, oral cleft defects, or childhood hematopoietic cancers.²⁶ The current study began with a survey to identify potential cases of the selected birth defects and childhood cancers. The study is also using water modeling²⁷ to help ATSDR determine the potential sources of past contamination and estimate when the water became contaminated and which housing units received the contaminated water. The water modeling data will help ATSDR identify which pregnant women may have been exposed to the contaminated water, and will also help ATSDR estimate the

²⁴Although there was no evidence of an increased rate of adverse pregnancy outcomes at Camp Lejeune at that time, the 1998 study report states that the agency believed it was prudent to research this topic because fetuses tend to be more sensitive to toxic chemical exposures and many pregnant women had resided in housing areas supplied with contaminated water. In addition to small for gestational age, other adverse pregnancy outcomes evaluated in the study included pre-term birth and mean birth weight.

²⁵U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry, *Volatile Organic Compounds in Drinking Water and Adverse Pregnancy Outcomes* (Atlanta, Ga.: 1998).

²⁶Childhood hematopoietic cancers include childhood leukemia and non-Hodgkin's lymphoma.

²⁷Water modeling is a scientific method that is used to help estimate past water system conditions.

amount of TCE and PCE that may have been in the drinking water. ATSDR officials said that the study is expected to be completed by December 2007.

Possible Adverse Health Effects of TCE and PCE

According to ATSDR's Toxicological Profile, inhaling small amounts of TCE may cause headaches, lung irritation, poor coordination, and difficulty concentrating, and inhaling or drinking liquids containing high levels of TCE may cause nervous system effects, liver and lung damage, abnormal heartbeat, coma, or possibly death.²⁸ ATSDR also notes that some animal studies suggest that high levels of TCE may cause liver, kidney, or lung cancer, and some studies of people exposed over long periods to high levels of TCE in drinking water or workplace air have shown an increased risk of cancer. ATSDR's Toxicological Profile notes that the National Toxicology Program has determined that TCE is reasonably anticipated to be a human carcinogen and the International Agency for Research on Cancer has determined that TCE is probably carcinogenic to humans. Unlike TCE, the health effects of inhaling or drinking liquids containing low levels of PCE are unknown, according to ATSDR. However, ATSDR reports that exposure to very high concentrations of PCE may cause dizziness, headaches, sleepiness, confusion, nausea, difficulty in speaking and walking, unconsciousness, or death.²⁹ HHS has determined that PCE may reasonably be anticipated to be a carcinogen.

²⁸ ATSDR did not define "small amounts" or "high levels" of TCE. According to ATSDR's Toxicological Profiles, when exposure to TCE or PCE occurs many factors determine whether an individual will be harmed. These factors include the amount of exposure, duration of exposure, and how an individual came in contact with these chemicals (i.e., ingestion, inhalation, or contact with the skin).

²⁹ ATSDR did not define "low levels" or "high concentrations" of PCE.

Efforts to Identify and Address Past Drinking Water Contamination at Camp Lejeune Began in the 1980s and Continue with Long-term Cleanup and Monitoring

Efforts to identify and address past drinking water contamination at Camp Lejeune began in the 1980s, when the Navy initiated water testing at Camp Lejeune. In 1980, one water test identified the presence of VOCs and a separate test indicated contamination by unidentified chemicals. In 1982 and 1983, water monitoring for TTHMs by a laboratory contracted by Camp Lejeune led to the identification of TCE and PCE as the contaminants in two water systems at Camp Lejeune. Sampling results indicated that the levels of TCE and PCE varied. Former Camp Lejeune environmental officials said they did not take additional steps to address the contamination after TCE and PCE were identified. The former officials recalled that they did not take additional steps because at that time they had little knowledge of TCE and PCE, there were no regulations establishing enforceable limits for these chemicals in drinking water, and variations in water testing results raised questions about the tests' validity. In 1984 and 1985, the NACIP program identified VOCs, including TCE and PCE, in 12 of the wells serving the Hadnot Point and Tarawa Terrace water systems. Camp Lejeune officials removed 10 wells from service in 1984 and 1985. Additionally, information about the contamination was provided to residents. Upon investigating the contamination, DOD and North Carolina officials concluded that both on- and off-base sources were likely to have caused the contamination in the Hadnot Point and Tarawa Terrace water systems. Since 1989, federal, state, and Camp Lejeune officials have partnered to take actions to clean up the sources of contamination and to monitor and protect the base's drinking water.

Navy Water Testing Beginning in 1980 Identified VOCs in Camp Lejeune Water Systems

The presence of VOCs in Camp Lejeune water systems was first detected in October 1980. On October 1, 1980, samples of water were collected from all eight water systems at Camp Lejeune by an official from LANTDIV, a Navy entity that provided environmental support to Camp Lejeune. The water samples were combined into a single sample, and a "priority pollutant scan" was conducted in order to detect possible contaminants in the water systems. The results of this analysis, conducted by a Navy-contracted private laboratory and sent to LANTDIV, identified 11 VOCs, including TCE, at their detection limits, that is, the lowest level at which the chemicals could be reliably identified by the instruments being used.³⁰

³⁰ Additionally, two metals—cadmium and selenium—were identified at levels slightly above detection limits.

Separately, in 1980 the Navy began monitoring programs for TTHMs at various Navy and Marine Corps bases, including Camp Lejeune, in preparation for meeting a future EPA drinking water regulation.³¹ LANTDIV arranged for an Army laboratory to begin testing the treated water from two Camp Lejeune water systems, Hadnot Point and New River, in October 1980. At that time, these two water systems were the only ones that served more than 10,000 people and therefore would be required to meet the future TTHM regulation. From October 1980 to September 1981, eight samples were collected from the Hadnot Point water system and analyzed for TTHMs. Results from four of the eight samples indicated the presence of unidentified chemicals that were interfering with the TTHM analyses.³² Reports for each of the four analyses contained an Army laboratory official's handwritten notes about the unidentified chemicals: two of the notes classified the water as "highly contaminated" and notes for the other two analyses recommended analyzing the water for organic compounds.

The exact date when LANTDIV officials began receiving results from TTHM testing is not known, and LANTDIV officials told us that they had no recollection of how or when the results were communicated from the Army laboratory. Available Marine Corps documents indicate that Camp Lejeune environmental officials³³ learned in July 1981 that LANTDIV had been receiving the results of TTHM testing and was holding the results until all planned testing was complete. Subsequently, Camp Lejeune environmental officials requested copies of the TTHM results that LANTDIV had received to date, and LANTDIV provided these results in

³¹According to an August 1980 memorandum, which cited a 1979 amendment to the National Interim Primary Drinking Water Regulations, LANTDIV initiated monitoring programs at various naval facilities, including Camp Lejeune, in order to develop a TTHM database prior to the effective dates for the enforcement of the maximum contaminant levels. For Camp Lejeune community water systems such as Hadnot Point and New River that served 10,000 to 74,999 individuals, the maximum contaminant levels for TTHMs took effect in November 1983 and an EPA requirement to begin monitoring TTHM levels in the systems began 1 year prior to that date. *See 44 Fed. Reg. 68641* (Nov. 29, 1979) (to be codified at 40 C.F.R. § 141.6).

³²The results from the other four samples did not note the presence of unidentified chemicals.

³³In the early 1980s the environmental staff at Camp Lejeune consisted of three primary staff members: a director specializing in natural resources, a supervisory ecologist, and a chemist. These staff members were responsible for water monitoring and compliance with environmental regulations, among other responsibilities. Over time as environmental laws have changed, the environmental staff has grown and obtained additional responsibilities.

August 1981. The next documented correspondence from LANTDIV to Camp Lejeune regarding TTHM monitoring occurred in a February 1982 memorandum in which LANTDIV recommended that TTHM monitoring be expanded to all of Camp Lejeune's water systems and noted that Camp Lejeune should contract with a North Carolina state-certified laboratory for the testing. Current and former LANTDIV officials recalled that their agency played a limited role in providing information or guidance regarding environmental issues at Camp Lejeune, and that this assistance generally would have been at the request of Camp Lejeune officials. However, former Camp Lejeune environmental officials recalled that at that time they had little experience in water quality issues and relied on LANTDIV to serve as their environmental experts.

Further Tests Identified TCE and PCE in Two Camp Lejeune Water Systems in 1982 and 1983; Camp Lejeune Officials Do Not Recall Taking Action to Address the Contamination at That Time

Following LANTDIV's recommendation to expand TTHM monitoring to all base water systems, Camp Lejeune officials contracted with a private state-certified laboratory to test samples of treated water from all eight of their water systems. According to an August 1982 memorandum, in May 1982 a Camp Lejeune official was informed during a telephone conversation with a private laboratory official that organic cleaning solvents, including TCE, were present in the water samples for TTHM monitoring from the Hadnot Point and Tarawa Terrace water systems. In July 1982, additional water samples from the two systems were collected in an effort to investigate the presence of these chemicals. In August 1982 the contracted laboratory sent a letter to base officials informing them that TCE and PCE were identified as the contaminants in the May and July samples. According to the letter, the testing determined that the Hadnot Point water system was contaminated with both TCE and PCE and the Tarawa Terrace water system was contaminated with PCE. The letter also noted that TCE and PCE "appeared to be at high levels" and were "more important from a health standpoint" than the TTHM monitoring. Sampling results indicated that the levels of TCE and PCE varied. The letter noted that one sample taken in May 1982 from the Hadnot Point water system contained TCE at 1,400 parts per billion and two samples taken in July 1982 contained TCE at 19 and 21 parts per billion. Four samples taken in May 1982 and July 1982 from the Tarawa Terrace water system contained levels of PCE that ranged from 76 to 104 parts per billion. (See table 2 for the May and July 1982 sampling results.)

Table 2: Sampling Results from Hadnot Point and Tarawa Terrace Water Systems for May 1982 and July 1982

Housing area	Samples^b	Concentrations of chemicals in parts per billion^a	
		TCE^c	PCE^d
May samples^e			
Hadnot Point	1	1,400	15
Tarawa Terrace	2	— ^f	80
July samples			
Hadnot Point	3	19	<1
	4	21	<1
	5	No data ^g	1.0
Tarawa Terrace	6	— ^f	76
	7	— ^f	82
	8	— ^f	104

Source: GAO analysis of Headquarters Marine Corps data.

^aThe August 1982 letter from the contracted laboratory that provided these sampling results did not include the detection limit. The detection limit is the lowest level at which the chemicals could be reliably identified by the instruments being used.

^bCamp Lejeune's samples were identified by nonconsecutive numbers. We renumbered the samples to provide consecutive number identifiers.

^cTrichloroethylene (TCE) is a volatile organic compound typically used as a metal degreaser.

^dTetrachloroethylene (PCE) is a volatile organic compound typically used as a dry cleaning solvent.

^eThe May samples were analyzed in July.

^fThe laboratory did not report results for TCE in these samples.

^gA memorandum by a Camp Lejeune environmental official indicated that this sample was analyzed for TCE, but exact quantities were not determined.

Former Camp Lejeune environmental officials recalled that after the private laboratory identified the TCE and PCE in the two water systems, they did not take additional steps to address the contamination for three reasons. First, they had limited knowledge of these chemicals; second, there were no regulations establishing enforceable limits for these chemicals in drinking water; and third, they made assumptions about why the levels of TCE and PCE varied and about the possible sources of the TCE and PCE. The former Camp Lejeune environmental officials told us that they were aware of EPA guidance, referred to as "suggested no adverse response levels," for TCE and PCE when these contaminants were identified at Camp Lejeune. However, they noted that the levels of these contaminants detected at Camp Lejeune generally were below those

outlined in the guidance. One Camp Lejeune environmental official also recalled that at the time they were unsure what the health effects would be for the lower amounts detected at the base. Additionally, in an August 1982 document and during our interviews with current Camp Lejeune environmental officials, it was noted that EPA had not issued regulations under the Safe Drinking Water Act for TCE and PCE when the private laboratory identified these chemicals in the drinking water. The former Camp Lejeune environmental officials also said that they made assumptions about why the levels of TCE and PCE varied. For example, they attributed the higher levels to short-term environmental exposures, such as spilled paint inside a water treatment plant, or to laboratory or sampling errors. Additionally, in an August 1982 memorandum, a Camp Lejeune environmental official suggested that based on the sampling results provided by the private laboratory, the levels of PCE detected could be the result of using coated pipes in the untreated water lines at Tarawa Terrace. The former Camp Lejeune environmental officials told us that in retrospect, it was likely that well rotation in these water systems contributed to the varying sampling results because the contaminated wells may not have been providing water to the Hadnot Point and Tarawa Terrace systems at any given time. However, both they and current Camp Lejeune environmental officials said that at that time the base environmental staff did not know that the wells serving both systems were rotated.

After August 1982, the private laboratory continued to communicate with Camp Lejeune officials about the contamination of treated water from the Hadnot Point and Tarawa Terrace water systems. All eight of Camp Lejeune's water systems were sampled again for TTHMs in November 1982. In a December 1982 memorandum, a Camp Lejeune environmental official noted that during a phone conversation with a chemist from the private laboratory the chemist expressed concern that TCE and PCE were interfering with Tarawa Terrace and Hadnot Point TTHM samples. The chemist said the levels of TCE and PCE were "relatively high" in the November 1982 samples, though the specific levels of TCE and PCE were not provided to Camp Lejeune officials. The private laboratory report providing the November 1982 results said that the samples from Tarawa Terrace "show contamination" from PCE and the samples from Hadnot Point "show contamination" from both TCE and PCE. All eight of Camp Lejeune's water systems were sampled again for TTHMs in August 1983, and the private laboratory report providing these results said that the samples from Tarawa Terrace "show contamination" from PCE and the samples from Hadnot Point "show contamination" from both TCE and

PCE.³⁴ Former Camp Lejeune environmental officials recalled that they did not take any actions related to these findings.

Discovery of Contamination in Individual Wells in 1984 and 1985 Prompted Their Removal from Service, and Information Was Provided to Residents and the Media

In 1982, Navy officials initiated the NACIP program at Camp Lejeune with an initial assessment study, which was designed to collect and evaluate evidence that indicated the existence of pollutants that may have contaminated a site or that posed a potential health hazard for people located on or off a military installation. The initial assessment study determined that further investigation was warranted at 22 priority sites and a confirmation study to investigate these sites was initiated in July 1984.

As a part of the confirmation study, a Navy contractor took water samples from water supply wells located near priority sites where groundwater contamination was suspected. Current and former Camp Lejeune officials told us that previous water samples usually had been collected from treated water at sites such as reservoirs or buildings within the water systems rather than being collected directly from individual wells at Camp Lejeune. In November 1984, Camp Lejeune officials received sampling results for one Hadnot Point well located near a priority site, which showed that TCE and PCE, among other VOCs, were detected in the well. This well was removed from service, and in December 1984, water samples from six Hadnot Point wells that were located in the same general area and treated water samples from the Hadnot Point water plant were also tested. Results of the analysis of the well samples indicated that both TCE and PCE were detected in one well, TCE was detected in two additional wells, and other VOCs were detected in all six wells. Results for the treated water samples also detected TCE and PCE. Four of these six wells were removed from service in addition to the original well removed from service. For the two wells that were not taken out of service, while initial results indicated levels of VOCs, including TCE, other test results showed no detectable levels of VOCs. Documents we reviewed show that continued monitoring of those two wells indicated no detectable levels of TCE. During December 1984, seven additional samples were taken from the treated water at Hadnot Point water plant and revealed no detectable levels of TCE and PCE. According to two former Camp Lejeune environmental officials, once the wells had been taken out of service and

³⁴The reports of the November 1982 and August 1983 TTHM analyses did not provide further details about the levels of TCE and PCE detected.

the samples from the water plant no longer showed detectable levels of TCE or PCE, they believed the water from the Hadnot Point water system was no longer contaminated.

Although the December 1984 testing of water from the Hadnot Point water system showed no detectable levels of TCE or PCE, in mid-January 1985 Camp Lejeune environmental staff began collecting water samples from all wells on the base. Sampling results were received in February 1985 and detected VOCs, including TCE and PCE, in 3 wells serving the Hadnot Point water system and 2 wells serving the Tarawa Terrace water system. As a result, those 5 wells were removed from service. According to current Camp Lejeune officials, all 10 wells had been removed from service by February 8, 1985. According to memoranda dated March 1985 and May 1985, 1 of the 2 wells removed from service at Tarawa Terrace was used on 1 day in March 1985 and on 3 days in April 1985 for short periods of time to meet water needs at the base. See table 3 for the dates that wells were removed from service and for the levels of TCE and PCE that were detected in the wells prior to their removal from service in 1984 and 1985. See app. I for the levels of all VOCs that were detected in the wells prior to their removal from service in 1984 and 1985.

Table 3: Dates Wells Were Removed from Service in 1984 and 1985 at Hadnot Point and Tarawa Terrace Water Systems, and TCE and PCE Levels Detected in Each Well Prior to Removal from Service

Water systems	Wells	Date removed from service	Concentrations of chemicals in parts per billion ^a	
			TCE ^b	PCE ^c
Hadnot Point	602	Nov. 30, 1984	1,600	24
	601	Dec. 6, 1984	210	5
	608	Dec. 6, 1984	110	ND
	634 ^d	Dec. 14, 1984	ND	ND
	637 ^d	Dec. 14, 1984	ND	ND
	651	Feb. 4, 1985	3,200	386
	652	Feb. 8, 1985	9	ND
	653	Feb. 8, 1985	5.5	ND
Tarawa Terrace	TT-26	Feb. 8, 1985	57	1,580
	TT-23 ^e	Feb. 8, 1985	ND	132

Source: GAO analysis of Headquarters Marine Corps data.

Notes: The detection limit for the instruments used to analyze the samples was 10 parts per billion. The detection limit is the lowest level at which the chemicals could be reliably identified by the instruments being used. A Marine Corps document providing the sampling results stated that ND meant "none detected."

^aThe concentrations provided are those detected prior to each well's removal from service and are one-time sampling results. We did not find documentation that tied the decision to remove the wells from service to any particular level of contamination included in related EPA guidance or enforceable regulation. DOD sampling also detected other VOCs. (See app. I.)

^bTrichloroethylene (TCE) is a volatile organic compound typically used as a metal degreaser.

^cTetrachloroethylene (PCE) is a volatile organic compound typically used as a dry cleaning solvent.

^dTCE and PCE were not detected in this well prior to its removal from service. Documents indicate that this well was taken out of service after detection of "significant levels" of methylene chloride, a VOC used in various industrial processes such as paint stripping, paint remover manufacturing, and metal cleaning and degreasing.

^eTarawa Terrace well TT-23 is also referred to as "TT-new well" in Marine Corps documents.

In addition, while base officials were waiting for sampling results from January 1985 of samples collected from wells serving Hadnot Point, water from this system was provided to a third water system for about 2 weeks. In late January 1985, a fuel line break caused gasoline to leak into the Holcomb Boulevard water treatment plant. During the approximately 2-week period the treatment plant was shut down, water from the Hadnot Point system was pumped into the Holcomb Boulevard water lines. Former Camp Lejeune environmental officials said that they used water

from the Hadnot Point water system because it was the only water system interconnected with the Holcomb Boulevard water system, and because they believed the water from the Hadnot Point water system was no longer contaminated. Prior to restarting the Holcomb Boulevard water system, samples of treated water were tested and no gasoline was detected in any of these samples. However, the samples were found to contain various levels of TCE; these results were attributed to the use of water from the Hadnot Point water system. About 5 days after these samples were taken, the Holcomb Boulevard water system was restarted because the fuel line had been repaired.

Following the discovery of contamination at individual wells in 1984, Camp Lejeune published articles in the base newspaper, provided one notification to residents of housing areas served by the Tarawa Terrace water system, and created a press release about issues related to drinking water at Camp Lejeune. In December 1984 the base newspaper published its first story about sampling efforts, detection of VOCs, and removal of wells from service in the Hadnot Point water system. At this time, Camp Lejeune environmental officials had not begun sampling all other wells on the base, including those at the Tarawa Terrace water system. Subsequently, in April 1985 the Commanding General of Camp Lejeune issued a notice to residents who lived in housing areas served by the Tarawa Terrace water system.³⁵ According to the notice:

“Two of the wells that supply Tarawa Terrace have had to be taken off line because minute (trace) amounts of several organic chemicals have been detected in the water. There are no definitive State or Federal regulations regarding a safe level of these compounds, but as a precaution, I have ordered the closure of these wells for all but emergency situations when fire protection or domestic supply would be threatened.”

The notice asked residents to reduce water use until early June, when the construction of a new water line was to be completed. In May 1985, another article in the base newspaper stated the number of wells that had been removed from service, stated why the wells were removed from service, and noted the potential for water shortage at Tarawa Terrace as a result. In addition, the Marine Corps provided us with copies of three North Carolina newspaper articles published from May 1985 to September

³⁵Documents do not indicate how this notice was provided to residents.

1985 discussing contamination at Camp Lejeune.³⁶ All three articles included information about the drinking water contamination and noted that 10 wells serving two water treatment systems at Camp Lejeune had been removed from service.

Past Contamination Was Estimated to Have Originated from Both On-base and Off-base Sources, and Cleanup Activities at These Sources Are Under Way

The sources of past contamination for the Hadnot Point water system have not been conclusively determined. However, DOD officials have estimated that eight contaminated on-base sites in the proximity of the Hadnot Point water system may be the sources of contamination for that water system. These eight sites were contaminated by leaking underground storage tanks containing fuel, by degreasing solvents, by hazardous chemical spills, and by other waste disposal practices.³⁷ Efforts by ATSDR are ongoing to conclusively determine the sources of past contamination in the Hadnot Point water system, as well as when the contamination began. For the Tarawa Terrace water system, North Carolina officials determined that the contamination likely came from a dry cleaning solvent that had been released into a leaking septic tank at an off-base dry cleaning facility—ABC One Hour Cleaners—which built its septic system and began operation in 1954. Both the dry cleaning facility and its septic tank were located off base but adjacent to a supply well for the Tarawa Terrace water system. Based on the environmental contamination at this site, ABC One Hour Cleaners was designated as a National Priorities List site in 1989. As part of its current health study, ATSDR has estimated that beginning as early as 1957 individuals were exposed to PCE in treated drinking water at levels equal to or greater than what became effective in 1992 as EPA's maximum contaminant level of 5 parts per billion.

Since 1989, officials from Camp Lejeune, North Carolina, and federal agencies, including EPA, have taken actions to clean up the suspected sources of the contamination in the Hadnot Point and Tarawa Terrace water systems. Because the contamination is thought to have come from both on- and off-base sources, and because those sources are part of two separate National Priorities List sites—Camp Lejeune and ABC One Hour

³⁶ According to a May 1985 memorandum, Camp Lejeune officials issued a press release regarding removal of wells from service at Camp Lejeune in May 1985. However, the memorandum did not describe the contents of the press release, and the Marine Corps was unable to locate a copy of the press release for our review.

³⁷ The sources of contamination at these eight sites were identified through the NACIP program and the Installation Restoration Program, which replaced NACIP as the Navy and Marine Corps environmental program.

Cleaners—cleanup activities for the suspected sources of contamination are being managed separately. Cleanup activities have included the removal of contaminated soils and gasoline storage tanks and the treatment of contaminated groundwater and soils.

Although ATSDR Did Not Always Receive Requested Funding and Experienced Delays in Receiving Information from DOD, Officials Said Their Work Has Not Been Significantly Delayed

Funding of ATSDR's Camp Lejeune Work

Since ATSDR began its Camp Lejeune-related work in 1991, the agency did not always receive requested funding and experienced delays in receiving information from DOD entities. Although concerns have been raised by former Camp Lejeune residents, ATSDR officials said these issues have not significantly delayed its work and that such situations are normal during the course of a study.

ATSDR received funding from DOD for 13 of the 16 fiscal years during which it has conducted its Camp Lejeune-related work, and ATSDR provided its own funding for Camp Lejeune-related work during the other 3 years. Under federal law and in accordance with a memorandum of understanding between DOD and ATSDR, DOD is responsible for funding public health assessments and any follow-up public health activities, such as health studies or toxicological profiles related to DOD sites as agreed to in an annual plan of work. For fiscal year 1997, funding for ATSDR's Camp Lejeune-related work came from the Navy.

From fiscal year 1998 through fiscal year 2000, no funding was provided to ATSDR by the Navy or any DOD entity for its Camp Lejeune-related work because the agencies could not reach agreement about the funding for Camp Lejeune. In June 1997, ATSDR proposed conducting a study of childhood leukemia and birth defects associated with TCE and PCE exposure at Camp Lejeune during fiscal years 1998 and 1999 at an estimated cost of almost \$1.8 million. In a July 1997 letter to the Navy, an ATSDR official noted that during a June meeting the Navy appeared to be reluctant to fund the proposed study; however, the official noted that DOD was liable for the costs of the study under federal law. In an October 1997 letter responding to ATSDR, a senior Navy official stated that the Navy did

not believe it should be required to fund ATSDR's proposed study because the cause of the contamination was an off-base source, ABC One Hour Cleaners. The Navy official said that it was more appropriate for ATSDR to seek funding for the study from the responsible party that caused the contamination.³⁸ However, ATSDR officials told us that while they expected that the study would focus primarily on contamination from the dry cleaner, the study was also expected to include people who were exposed to on-base sources of contamination. An ATSDR official reported that the agency submitted its funding proposals for the Camp Lejeune study to DOD in each of the annual plans of work from fiscal year 1998 to fiscal year 2000, but that during that time period the agency received no DOD funding and funded its Camp Lejeune-related work from general ATSDR funding.

In fiscal year 2001 the Navy resumed funding of ATSDR's Camp Lejeune-related work. We could not determine why the Navy decided to resume funding of ATSDR's work at that time. Since fiscal year 2003, funding for ATSDR's Camp Lejeune-related work has been provided by the Marine Corps. According to a DOD official, the Marine Corps has committed to funding the current ATSDR study. The DOD official also noted that per a supplemental budget request from ATSDR for fiscal year 2006, the Marine Corps agreed to fund community assistance panel meetings and portions of a feasibility assessment for future studies that will include computerization of Camp Lejeune housing records.

Provision of Information to ATSDR by DOD

ATSDR has experienced some difficulties obtaining information from Camp Lejeune and DOD officials. For example, while conducting its public health assessment in September 1994, ATSDR sent a letter to the Department of the Navy noting that ATSDR had had difficulties getting documents needed for the public health assessment from Camp Lejeune, such as Remedial Investigation³⁹ documents for Camp Lejeune. The letter

³⁸ Additionally, the EPA Criminal Investigation Division, which conducted an investigation related to the drinking water contamination at Camp Lejeune, concluded that funding for the current study was apparently delayed because of opposition characterized as a professional difference of opinion as to the scientific value of the study by a midlevel manager at the Navy Environmental Health Center.

³⁹ A Remedial Investigation is performed at a site after it is listed on the National Priorities List. The Remedial Investigation serves as a mechanism for collecting data. Data collected during the Remedial Investigation influence the development of remedial alternatives for the site.

also noted that ATSDR had sent several requests for information, and Camp Lejeune's responses had been in most cases inadequate and no supporting documentation had been forwarded. ATSDR also had difficulty in obtaining access to DOD records while preparing to conduct its survey, the first phase of the current ATSDR health study. In October 1998, ATSDR requested assistance from the Defense Manpower Data Center, which maintains archives of DOD data, in locating residents of Camp Lejeune who gave birth between 1968 and 1985 on or off base. An official at the Defense Manpower Data Center initially did not provide the requested information because he believed that doing so could constitute a violation of the Privacy Act.⁴⁰ Between February and April 1999, Headquarters Marine Corps facilitated discussion between ATSDR and relevant DOD entities about these Privacy Act concerns and some information was subsequently provided to ATSDR by DOD. In April 2001, Headquarters Marine Corps sent a letter to the Defense Privacy Office suggesting that the Defense Manpower Data Center had only provided a limited amount of information to ATSDR.⁴¹ However, in a July 2001 reply to Headquarters Marine Corps, the Defense Privacy Office noted that it believed that relevant data had been provided to ATSDR by the Defense Manpower Data Center in 1999 and 2001.

In December 2005, ATSDR officials told us that they had recently learned of a substantial number of additional documents that had not been previously provided to them by Camp Lejeune officials. ATSDR then sent a letter to Headquarters Marine Corps seeking assistance in resolving outstanding issues related to delays in the provision of information and data to ATSDR. In an attachment to the letter, ATSDR provided a list of data and information needed from the Marine Corps in order to complete water modeling activities for its current study. In a January 2006 response, a Headquarters Marine Corps official noted that a comprehensive review was conducted of responses to ATSDR's requests for information and that the Marine Corps believed it had made a full and timely disclosure of all known and available requested documents. The official also noted that while ATSDR had requested that the Marine Corps identify and provide

⁴⁰The Privacy Act of 1974 provides safeguards for individuals against invasions of privacy as a result of the collection of personal information by the federal government. Pub. L. No. 93-579, § 3, 88 Stat. 1896, 1897 (codified as amended at 5 U.S.C. § 552a).

⁴¹The Defense Privacy Office is responsible for implementation of DOD's Privacy Program, which regulates how and when DOD collects, maintains, uses, or disseminates personal information on individuals.

documents that were relevant or useful to ATSDR's study, the Marine Corps did not always have the subject matter expertise to determine the relevance of documents. The official noted that the Marine Corps would attempt to comply with this request; however, the official also noted that ATSDR was the agency with the expertise necessary to determine the relevance of documents.

Effect on ATSDR's Work

Despite difficulties, ATSDR officials said the agency's Camp Lejeune-related work had not been significantly delayed or hindered by DOD. Officials said that while funding and access to records were probably slowed down and made more expensive by DOD officials' actions, their actions did not significantly impede ATSDR's health study efforts. The ATSDR officials also stated that while issues such as limitations in access to DOD data had to be addressed, such situations are normal during the course of a study. The officials stated that ATSDR's progress on the study has been reasonable in light of the complexity of the project. Nonetheless, as some former residents have learned that ATSDR has not always received requested funding and information from DOD entities, they have raised questions about DOD's commitment to supporting ATSDR's work.⁴² For example, when some former residents learned during a community assistance panel meeting that it took about 4 months for DOD to respond to a supplemental budget request from ATSDR for fiscal year 2006, they questioned DOD entities' commitment to ATSDR's Camp Lejeune-related work. However, DOD and ATSDR officials described this delay in responding as typical during the funding process.

⁴²The Marine Corps has issued multiple public statements indicating support for ATSDR's work at Camp Lejeune.

Experts Convened by NAS Generally Agreed That Many Parameters of ATSDR's Current Study Were Appropriate

Study Population

The seven members of an expert panel convened by NAS at our request generally agreed that specific parameters of ATSDR's current study were appropriate, including the study population, the exposure time frame, and the selected health effects. The expert panel members had mixed opinions on ATSDR's projected completion date.

The seven panel experts concurred that ATSDR logically limited its study population to those individuals who were in utero while their mothers were pregnant and lived at Camp Lejeune during the 1968 through 1985 time frame, and who may have been exposed to the contaminated drinking water.⁴³ The current study follows recommendations from the agency's 1997 public health assessment of Camp Lejeune, which noted that studies of cancer among those who were exposed in utero should be conducted to further the understanding of the health effects in this susceptible population. Panel experts said that ideally a study would attempt to include all individuals who were potentially exposed, but that limited resources and data availability were practical reasons for limiting the study population. Additionally, panel experts agreed that those exposed while in utero were an appropriate study population because they could be considered at higher risk of adverse health outcomes than others, such as those exposed as children or adults. In addition, two panel experts said that studying only those who lived on base was reasonable because they likely had a higher risk of inhalation exposure to VOCs such as TCE and PCE, which may be more potent than ingestion exposure.⁴⁴ Thus, pregnant women who lived in areas of base housing with contaminated water and

⁴³ATSDR's current study population of those individuals who were in utero includes individuals whom ATSDR determined were exposed during specific time periods of the mother's pregnancy or after their birth to contaminated drinking water because they lived in an area that was served by the Hadnot Point or Tarawa Terrace water systems, and those that ATSDR determined through its study analysis were not exposed because they did not live in those areas or were not exposed during specific time periods.

⁴⁴According to ATSDR, inhalation of TCE and PCE that have evaporated from drinking water is likely to result in higher exposures than ingestion. Additionally, 1991 EPA guidance on estimating exposure to VOCs during showering noted that scientific studies found that this exposure is approximately equivalent to exposure from ingesting two liters of the contaminated water per day.

conducted activities during which they could inhale water vapor—such as bathing, showering, or washing dishes or clothing—likely faced greater exposure than those who did not live on base but worked on base in areas served by the contaminated drinking water.

Study Time Frame	The seven panel experts agreed that the 1968 through 1985 study time frame was reasonable, based on limitations in data availability. This time frame was adopted from ATSDR's 1998 study of adverse pregnancy outcomes, which limited the study population to include those potentially exposed between 1968 and 1985. According to ATSDR's study protocol, these years were chosen because 1968 was the first year that birth certificates were computerized in North Carolina and 1985 was when the affected water wells were removed from service. Four of the panel experts said they did not see any benefit in using an earlier start date than 1968 because collecting birth records before 1968 could require a significant amount of resources to collect data. In addition, while the initial exposure to contaminated drinking water may have occurred as early as the 1950s, at the time the ATSDR study time frame was selected officials were unable to determine precisely when the contamination began. Four of the panel experts commented that exposure was likely highest in the latter part of the study time frame—presumably, they said, as a result of a higher accumulated level of contamination over time—thus making the uncertainty of when the contamination began less significant and supporting ATSDR's decision to study the later time frame.
Study Health Effects	The five panel experts who discussed health effects said that those selected for the study were valid for individuals who were potentially exposed in utero at Camp Lejeune. ⁴⁵ Based on previous ATSDR work and existing literature, the health effects chosen for the study were neural tube defects, oral cleft defects, and childhood hematopoietic cancers, including leukemia and non-Hodgkin's lymphoma. ⁴⁶ Two panel experts said that

⁴⁵The two panel experts who did not discuss health effects said that this discussion was outside their areas of expertise. One expert is a professor of geochemistry and the second is an environmental engineer.

⁴⁶An ATSDR document listing frequently asked questions about its health study states that the agency chose to study these birth defects and cancers based on the results of previous studies; two previous studies suggested that the chemicals in the drinking water at Camp Lejeune might cause these birth defects, while three studies suggested that these chemicals in drinking water might cause childhood leukemia. Additionally, ATSDR's study protocol noted that ATSDR's study could add to the body of scientific knowledge.

ATSDR had limited its study to health effects that are rare and that generally occur at higher levels of exposure to VOCs such as TCE and PCE than are expected to have occurred at Camp Lejeune. They said that this may result in ATSDR not identifying enough individuals with these health effects to determine meaningful results in the study.⁴⁷

Study Completion Date

ATSDR has projected a December 2007 completion date for the study, which would include activities such as identifying and enrolling study participants, conducting a parental interview, confirming each reported diagnosis, modeling the water system to quantify the amount and extent of each individual's exposure, analyzing the data, and drafting a final report. Panel experts had mixed opinions regarding ATSDR's completion date. Of the five panel experts who commented on the proposed completion date, three said that the date appeared reasonable, and two others said that based on the complexity of the water modeling the projected completion date might be optimistic.⁴⁸

Mr. Chairman, this completes my prepared statement. I would be happy to respond to any question you or other Members of the Subcommittee may have at this time.

Contacts and Acknowledgments

For further information about this testimony, please contact Marcia Crosse at (202) 512-7119 or crossem@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this testimony. Bonnie Anderson, Assistant Director; Karen Doran, Assistant Director; Danielle Organek; and Christina Ritchie made key contributions to this testimony.

⁴⁷ ATSDR's public health assessment noted that the exposure levels experienced at Camp Lejeune were expected to be relatively low and experienced over a relatively short duration.

⁴⁸ One of the panel experts did not discuss the completion date of the study. A second expert said he did not have sufficient data to make a determination on whether the projected completion date was reasonable.

Appendix I: Volatile Organic Compounds Detected in Wells at Hadnot Point and Tarawa Terrace Water Systems

Water systems	Wells	Date removed from service	Concentrations of chemicals in parts per billion ^a							
			TCE ^b	PCE ^c	Benzene ^d	Trans-1,2-DCE ^e	1,1-DCE ^f	Methylene chloride ^g	Toluene ^h	Vinyl chloride ⁱ
Hadnot Point	602	Nov. 30, 1984	1,600	24	120	630	2.4	—	5.4	18
	601	Dec. 6, 1984	210	5	ND	88	ND	ND	ND	ND
	608	Dec. 6, 1984	110	ND	3.7	5.4	ND	ND	ND	ND
	634	Dec. 14, 1984	ND	ND	ND	2.3	—	130	—	ND
	637	Dec. 14, 1984	ND	ND	ND	ND	—	270	—	—
	651	Feb. 4, 1985	3,200	386	—	3,400	187	—	—	655
	652	Feb. 8, 1985	9	ND	—	ND	ND	—	—	ND
	653	Feb. 8, 1985	5.5	ND	—	ND	ND	—	—	ND
Tarawa Terrace	TT-26	Feb. 8, 1985	57	1,580	ND	92	—	—	—	27
	TT-23 ^j	Feb. 8, 1985	ND	132	ND	11	—	—	—	ND

Source: GAO analysis of Headquarters Marine Corps data.

Notes: The detection limit for the instruments used to analyze the samples was 10 parts per billion. The detection limit is the lowest level at which the chemicals could be reliably identified by the instruments being used. A Marine Corps document providing the sampling results stated that ND meant "none detected." Where no concentration or ND is provided, the laboratory did not report results for these samples.

^aThe concentrations provided are those detected prior to each well's removal from service in 1984 and 1985 and are one-time sampling results. We did not find documentation that tied the decision to remove the wells from service to any particular level of contamination included in related Environmental Protection Agency (EPA) guidance or enforceable regulation.

^bTrichloroethylene (TCE) is a volatile organic compound typically used as a metal degreaser.

^cTetrachloroethylene (PCE) is a volatile organic compound typically used as a dry cleaning solvent.

^dBenzene is a widely used chemical formed from both natural processes and human activities. Some industries use benzene to make other chemicals which are used to make plastics, resins, and nylon and synthetic fibers. Benzene is also a natural part of crude oil, gasoline, and cigarette smoke. Breathing benzene can cause drowsiness, dizziness, and unconsciousness; long-term benzene exposure causes effects on the bone marrow and can cause anemia and leukemia. The Department of Health and Human Services (HHS) has determined that benzene is a known carcinogen.

^eTrans-1,2-dichloroethylene (Trans-1,2-DCE) is an odorless organic liquid used as a solvent for waxes and resins; in the extraction of rubber; as a refrigerant; in the manufacture of pharmaceuticals and artificial pearls; in the extraction of oils and fats from fish and meat; and in making other organics. EPA has found trans-1,2-DCE to potentially cause central nervous system depression when people are exposed to it at levels above 100 parts per billion for relatively short periods of time. Trans-1,2-DCE has the potential to cause liver, circulatory, and nervous system damage from long-term exposure at levels above 100 parts per billion.

^f1,1-dichloroethylene (1,1-DCE) is an organic liquid with a mild, sweet, chloroform-like odor. Virtually all of it is used in making adhesives, synthetic fibers, refrigerants, food packaging, and coating resins. EPA has found 1,1-DCE to potentially cause liver damage when people are exposed to it at levels above 7 parts per billion for relatively short periods of time. In addition, 1,1-DCE has the potential to cause liver and kidney damage as well as toxicity to the developing fetus and cancer from a lifetime exposure at levels above 7 parts per billion.

**Appendix I: Volatile Organic Compounds
Detected in Wells at Hadnot Point and Tarawa
Terrace Water Systems**

⁹Methylene chloride is a volatile organic compound used in various industrial processes, including paint stripping, paint remover manufacturing, and metal cleaning and degreasing. Breathing in large amounts of methylene chloride can damage the central nervous system. Contact of eyes or skin with methylene chloride can result in burns. HHS has determined that methylene chloride can be reasonably anticipated to be a cancer-causing chemical.

¹⁰Toluene is a clear, colorless liquid which occurs naturally in crude oil and in the tolu tree. It is also produced in the process of making gasoline and other fuels from crude oil and making coke from coal. Toluene may affect the nervous system. Low to moderate levels can cause tiredness, confusion, weakness, drunken-type actions, memory loss, nausea, loss of appetite, and hearing and color vision loss. Inhalation of high levels of toluene in a short time can result in feelings of light-headedness, dizziness, or sleepiness. It can also cause unconsciousness, and even death. High levels of toluene may affect kidneys. Studies in humans and animals generally indicate that toluene does not cause cancer.

¹¹Vinyl chloride is a colorless gas. It is a manufactured substance that does not occur naturally. It can be formed when other substances such as trichloroethane, TCE, and PCE are broken down. Breathing high levels of vinyl chloride for short periods of time can cause dizziness, sleepiness, and unconsciousness and at extremely high levels can cause death. Breathing vinyl chloride for long periods of time can result in permanent liver damage, immune reactions, nerve damage, and liver cancer. HHS has determined that vinyl chloride is a known carcinogen.

¹²Well TT-23 is also referred to as "TT-new well" in Marine Corps documents.

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